

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

NACA TM 16

SOME NEW TESTS AT THE GOTTINGEN LABORATORY

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
WASHINGTON, DC

APR 21

NACA-TM-16
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

T. M. 16

SOME NEW TESTS AT THE GOTTINGEN LABORATORY.

Prepared by
Paris Office, N.A.C.A.

April, 1921.

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

NOTICE

THIS DOCUMENT HAS BEEN REPRODUCED FROM THE BEST COPY FURNISHED US BY THE SPONSORING AGENCY. ALTHOUGH IT IS RECOGNIZED THAT CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED IN THE INTEREST OF MAKING AVAILABLE AS MUCH INFORMATION AS POSSIBLE.

SOME NEW TESTS AT THE GÖTTINGEN LABORATORY.

To the kindness of Professor Prandtl, Director of the Göttingen Laboratory, we owe the results of some recent tests, namely:

1) FRICTION TESTS ON A SURFACE TREATED WITH EMAILLITE.

The results of these tests, and also those of Gebers and Gibbons have been represented on Fig. 1, Pl.A.4, by laying of the Logarithms of Vl/v in abscissas, and the logarithms of the coefficients of resistances C_r in ordinates.

The product Vl/v , or Reynolds number, is a dimensionless magnitude and therefore independent of the system of units adopted. We may recall that the value of the kinematic coefficient of viscosity γ is $\frac{13.3}{10^6}$ m²/sec. for air at 760 mm. and 0°; $\frac{24.5}{10^6}$ m²/sec. for air at 760 mm. and 100°, and $\frac{1330}{10^6}$ for air at 7.6 mm. and 0°.

For water this coefficient is $\frac{1.8}{10^6}$ for 0° and $\frac{0.3}{10^6}$ for 100°.

The coefficient of resistance $C_r = \frac{R}{S \cdot \rho \frac{V^2}{2}}$ where R is the total resistance, S the area of friction, ρ the density, and V the speed; this again is a dimensionless magnitude.

The relation between this coefficient and that employed at the Eiffel Laboratory (k_f) is as follows:

$$k_f \text{ (kg/m}^2\text{/m:sec. at 15° and 760 mm.)} = c_r/13.$$

The results of the Göttingen tests may be represented very exactly by the formula:

$$C_r = 0.00376 \quad \frac{V_1}{V}^{-0.15}$$

2) VERIFICATION TESTS ON THE M.V.A. 358 WING.

The first tests on this surface were described in the "Zeitschrift für Flugtechnik und Motorluftschiffahrt," of May 31st, 1919, in an article by Mr. Krumbach: "Tests for the establishment of Laws of Similitude with respect to Aerofoils."

It will be remembered that these tests were made on surfaces of great depth placed between two vertical walls and that they served for estimating the probable results of tests of the same wings of any aspect ratio whatever.

Concerning the results of the tests of one of these wings (M.V.A.358) we have pointed out that we considered the resistance too low, for it was less than the friction resistance.

These tests were made while the war was still on, and the experimenters had evidently not time to check their results very carefully. They have therefore been taken up again recently and on Fig. 2, Pl.A.4 we give the results of the new tests on the M.V.A.358 wing. We see that the true resistance is appreciably greater and that it is no longer less than the friction resistance.

We recall that:

$$C_a = \frac{100 A}{F \rho \frac{v^2}{2}} = 1600 k_y = 200 L_c$$

$$C_{w_0} = \frac{100 \cdot W_0}{F \rho \frac{v^2}{2}} = 1600 k_{x_0} = 200 D_c$$

A being the lift and W_0 the profile resistance, F , the surface, ρ the density, v the speed, k_y and k_{x_0} the coefficients of the Eiffel Laboratory, and L_c and D_c the coefficients of the N.P.L.; E is the product of the speed and the depth of the wing.

We would recall that the superposition of a system of iso-speeds and iso-altitudes on the polar of the wing permits of the immediate reading of horizontal speed at any altitude whatever.

We see that, contrary to what might have been thought from the first tests, the full scale results are not appreciably superior to the estimates based on model tests, provided that $E > 4200$.

We must, however, consider the results (curve III) given by wing 358 as superior to those found in a general way at the Eiffel Laboratory and at the N.P.L.

3) COMPARATIVE TESTS OF WING NO. 36 AT THE EIFFEL LABORATORY.

On Fig. 3, Pl.A.4, we have plotted the polars of wing 36 by the tests of the Eiffel Laboratory reduced to aspect ratio 5 by Prandtl's formulas, and by the Göttingen Laboratory tests made on a model of aspect ratio 5.

This comparison shows that the Göttingen tests give much better results than those of the Auteuil Laboratory.

It is not possible to attribute these differences to a difference of models due to the fact that the Göttingen model was made from a drawing of the model tested at Auteuil. It is perhaps partly owing to the fact that the theoretical coefficient π figuring in Prandtl's transformation formulas is not applicable to this wing, as is the case for certain experiments on aspect ratio.

On this subject we may mention other experiments of different laboratories on the same wings. First, there are the tests of the N.P.L. and of the Eiffel Laboratory on models of full scale wings tested on the truck of the St.Cyr Aerotechnical Institute. We have also the experiments of the Laboratory of the Central Aeronautical Institute of Rome on wings 33 (Bréguet) and 38 (Coanda) of the Eiffel Laboratory.* Lastly, we have our own experiments at the Eiffel Laboratory on models of wings R.H. F.14, 15, and 16 of the N.P.L.

THE EXAMINATION OF ALL THESE EXPERIMENTS LEADS TO THE BELIEF THAT, AT LARGE INCIDENCES, THE SPEEDS REGISTERED BY THE SUCTION MANOMETER OF THE TESTING CHAMBER OF THE EIFFEL LABORATORY WIND TUNNEL ARE, OWING TO PRESSURE DROP, GREATER THAN THE ACTUAL SPEEDS AND THAT, THEREFORE, THE VALUES OF k_x and k_y MEASURED AT THE EIFFEL LABORATORY AT LARGE INCIDENCES, ARE TOO LOW.

* Istituto Sperimentale Aeronautico "Attività della Sezione airo-idro-dinamica." Giugno 1916 - Giugno 1917, p. 391, 391a, 334, 334a.

4) TESTS ON THE INFLUENCE OF ASPECT RATIO ON THE MONOPLANE WING No. 329.

The Göttingen Laboratory made these tests by employing wings of aspect ratio 1, 2, 3, 4, 5, 6, and 7. The results were then reduced to aspect ratio 5 by Prandtl's formulas, see Pl.B.34. We see that they perfectly verify the exactitude of these formulas.

5) REMARK BY PROFESSOR PRANDTL ON THE TESTS AT HIGH SPEED MADE BY Mr. CALDWELL AND Mr. FALES.

Speaking of these experiments which he considers "extremely important," Mr. Prandtl remarks that it is probable that for the second critical speed the velocity of sound is exceeded on the back of the wing and that, therefore, for determining the law of similitude we must not bring in the product $E \quad V.t$ (speed by depth of wing) as is done for viscous but non-compressible fluids, but that we must take into account the speed alone, as required by compressible fluids.

In other words, if we test similar wings of different depths, the first critical regime will occur when the product Vt is the same, while the second critical regime will be established for the same speed, whatever be the depth of the wing.

In support of his opinion, Mr. Prandtl has had plotted on Pl.A.5 the variation of k_y in function of the product $V.t$ for the wing of camber 0.2 tested at McCook Field and for a wing of the same camber tested at Göttingen and for which he has obtained products $V.t$ five times greater. He notes that the first crit-

ical regime takes place for practically similar values of $V.t$, but that, in accordance with his estimates, not having reached the value of the second critical speed, the second critical regime was not obtained.

In order to verify his ideas, Mr. Prandtl suggests testing the same wing with an aspect ratio of 1 : 3, say; we should then see whether the second regime was established for the same product $V.t$ or for the same speed V .

We may summarize Mr. Prandtl's considerations from a practical point of view by saying that it is not possible to estimate the results of full scale tests by tests of very small models at very high speeds.

SOME NEW TESTS AT THE GOTTINGEN LABORATORY

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS PARIS OFFICE

DESIGNED
DRAWN *Mont 7-6-32*
CHECKED
APPROVED

A4

FIG. 1 FRICTION TESTS

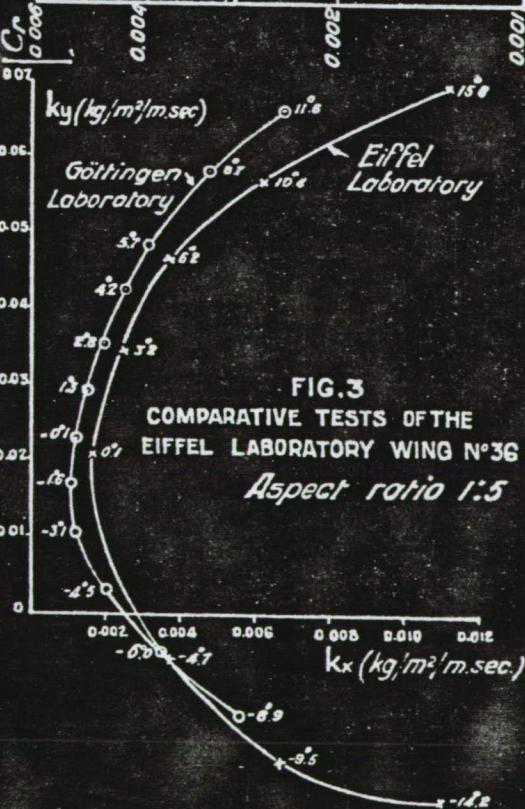
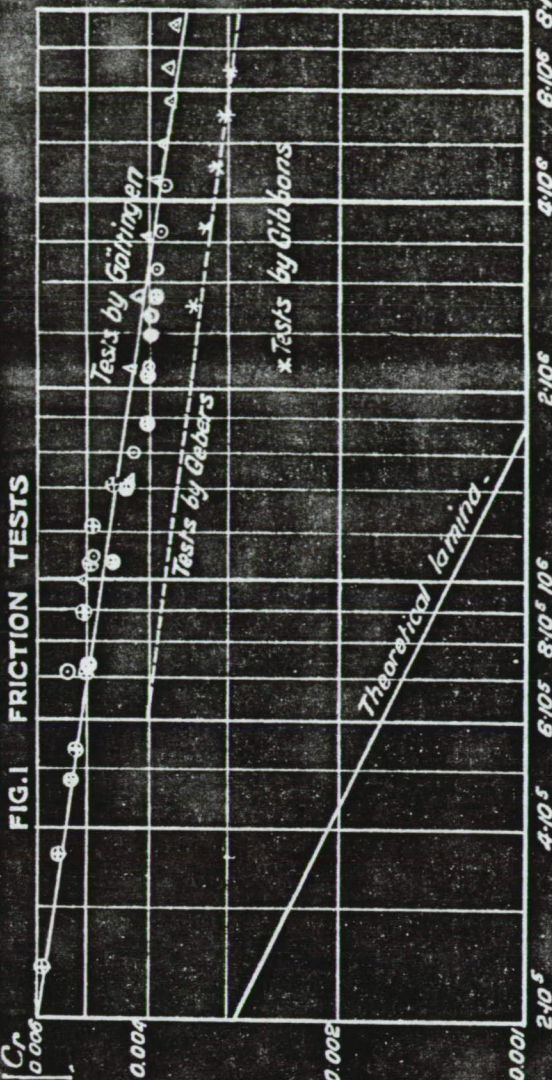
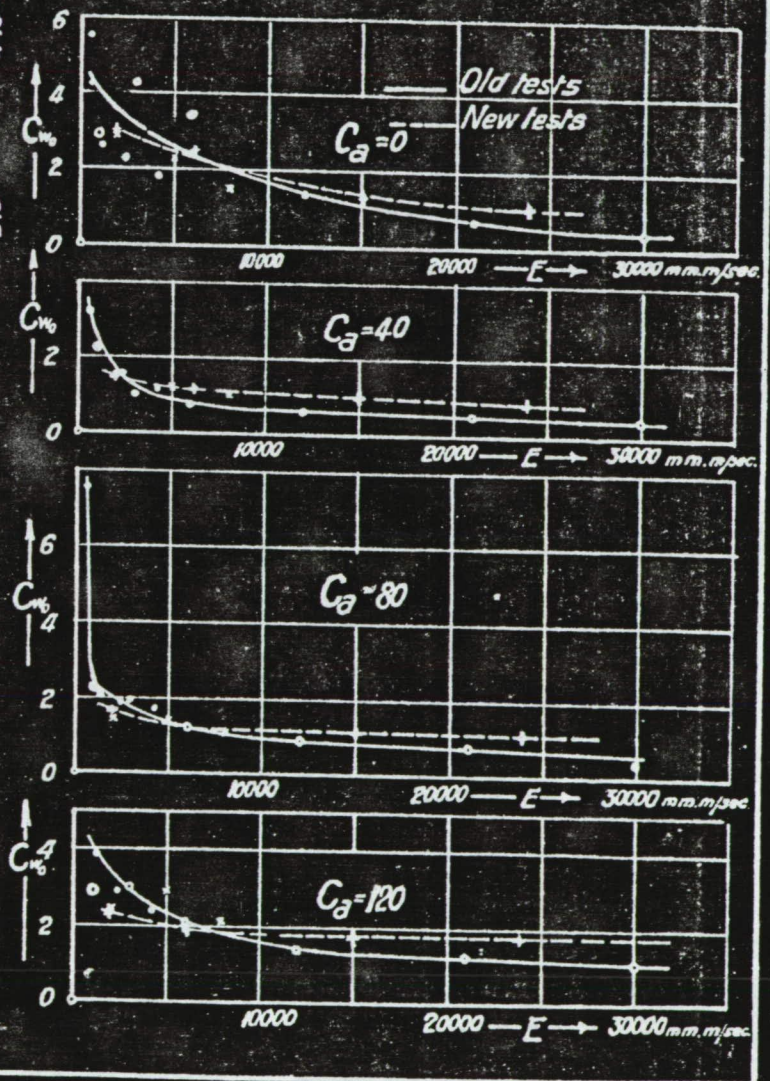


FIG. 2
VERIFICATION TESTS OF THE SURFACE M.V.A. 358

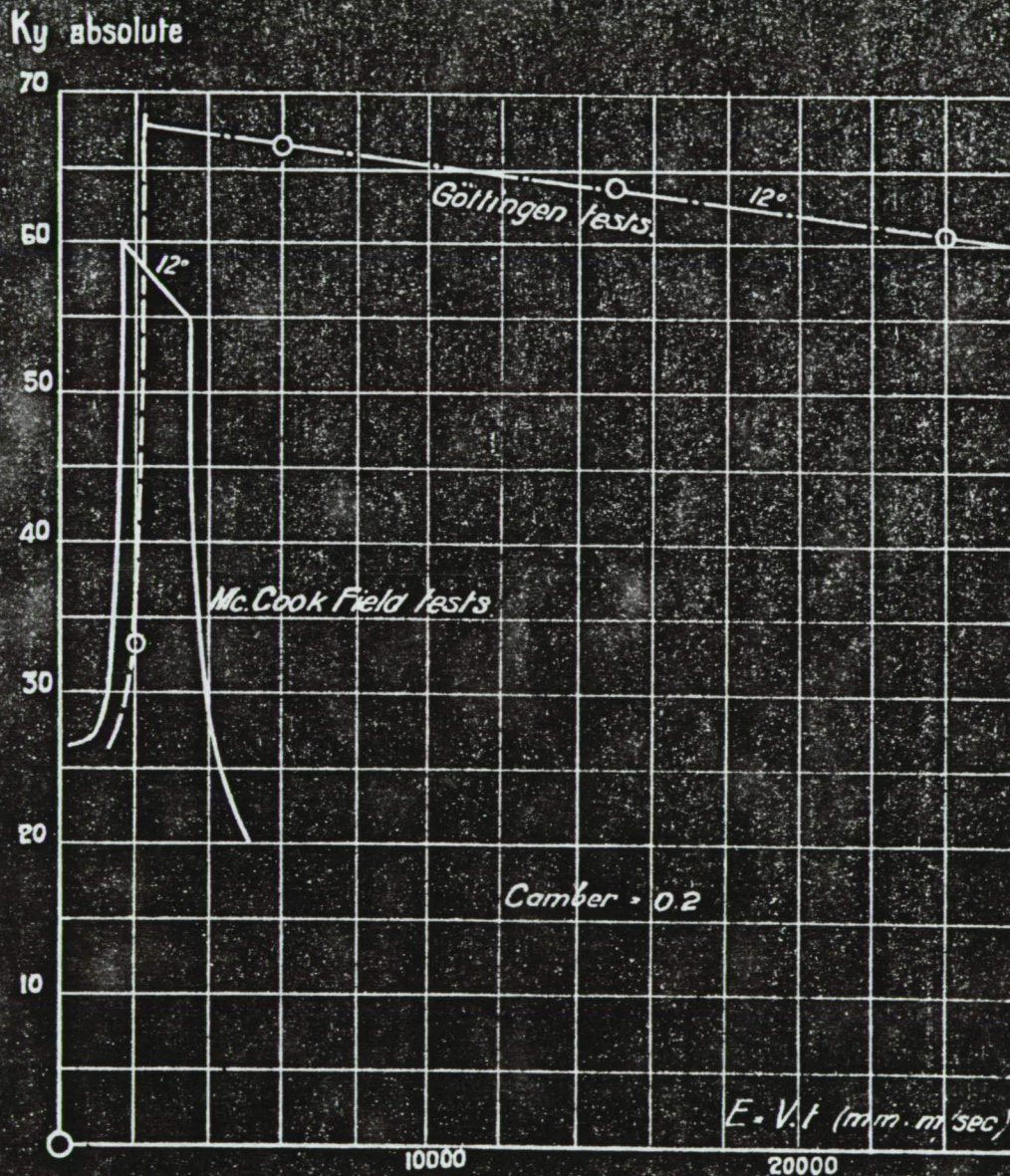


COMPARISON OF THE Mc. COOK FIELD AND GÖTTINGEN TESTS

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS PARIS OFFICE

DESIGNED
DRAWN *Feb 7/26/76*
CHECKED
APPROVED

A5

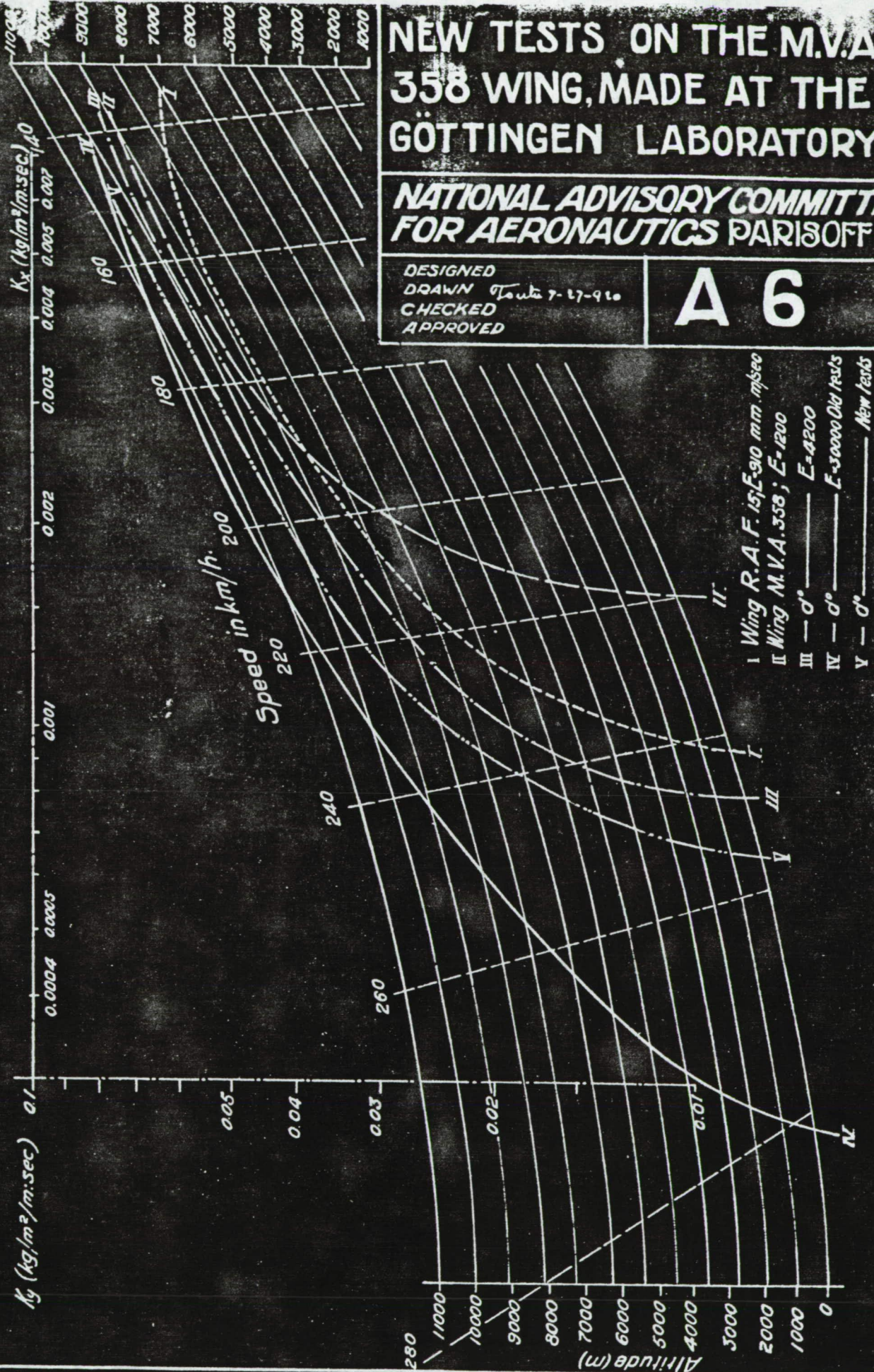


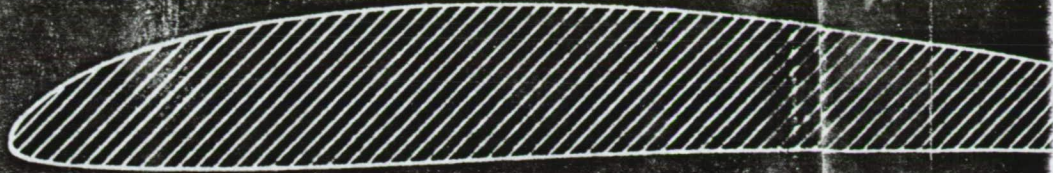
NEW TESTS ON THE M.V.A. 358 WING, MADE AT THE GÖTTINGEN LABORATORY

**NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS** PARIS OFFICE

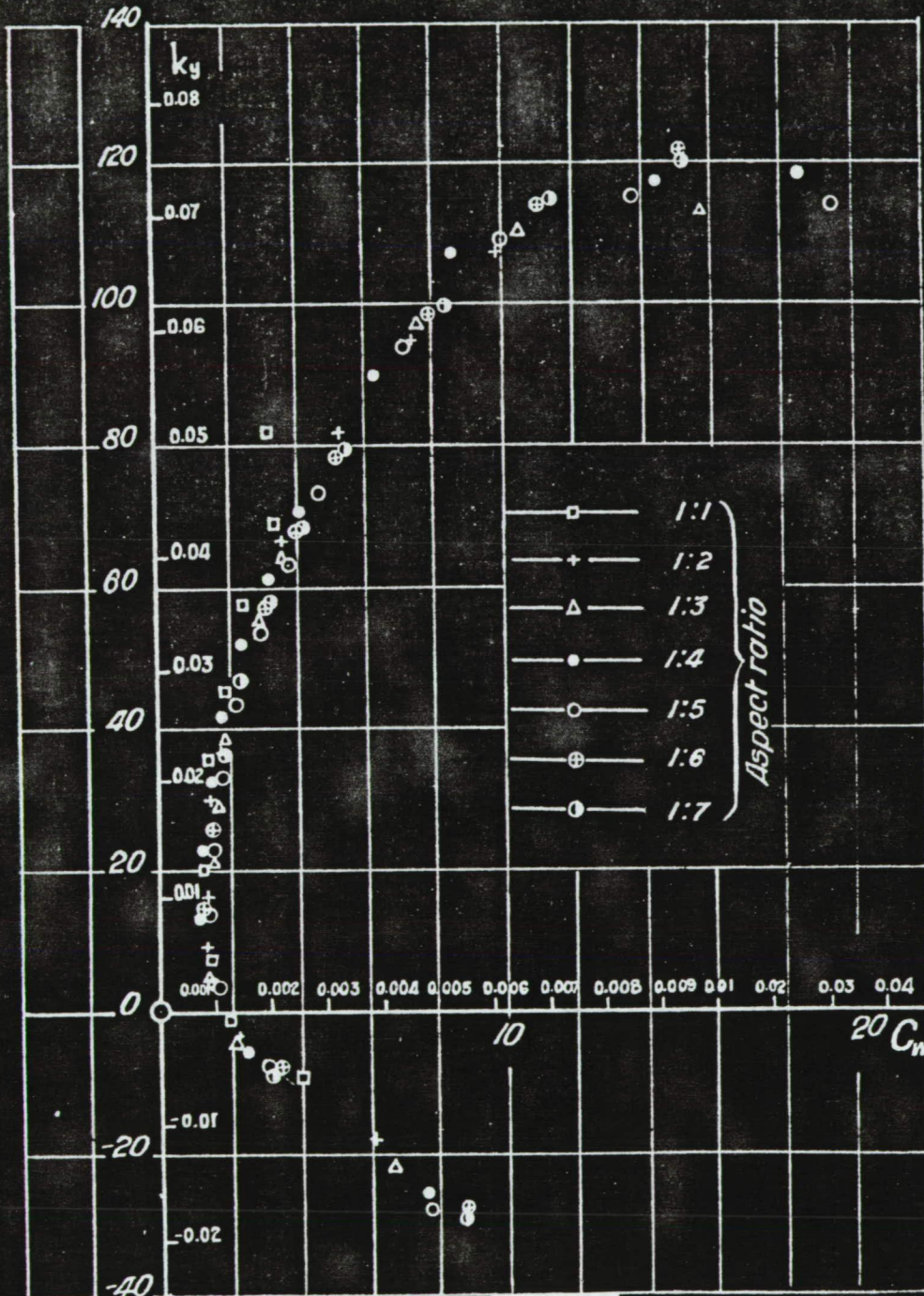
DESIGNED
DRAWN *7-27-910*
CHECKED
APPROVED

A 6





C_a REDUCED POLARS AT ASPECT RATIO 1:5



SOME NEW TESTS AT THE GOTTINGEN LABORATORY

WING N° 389

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS PARIS OFFICE

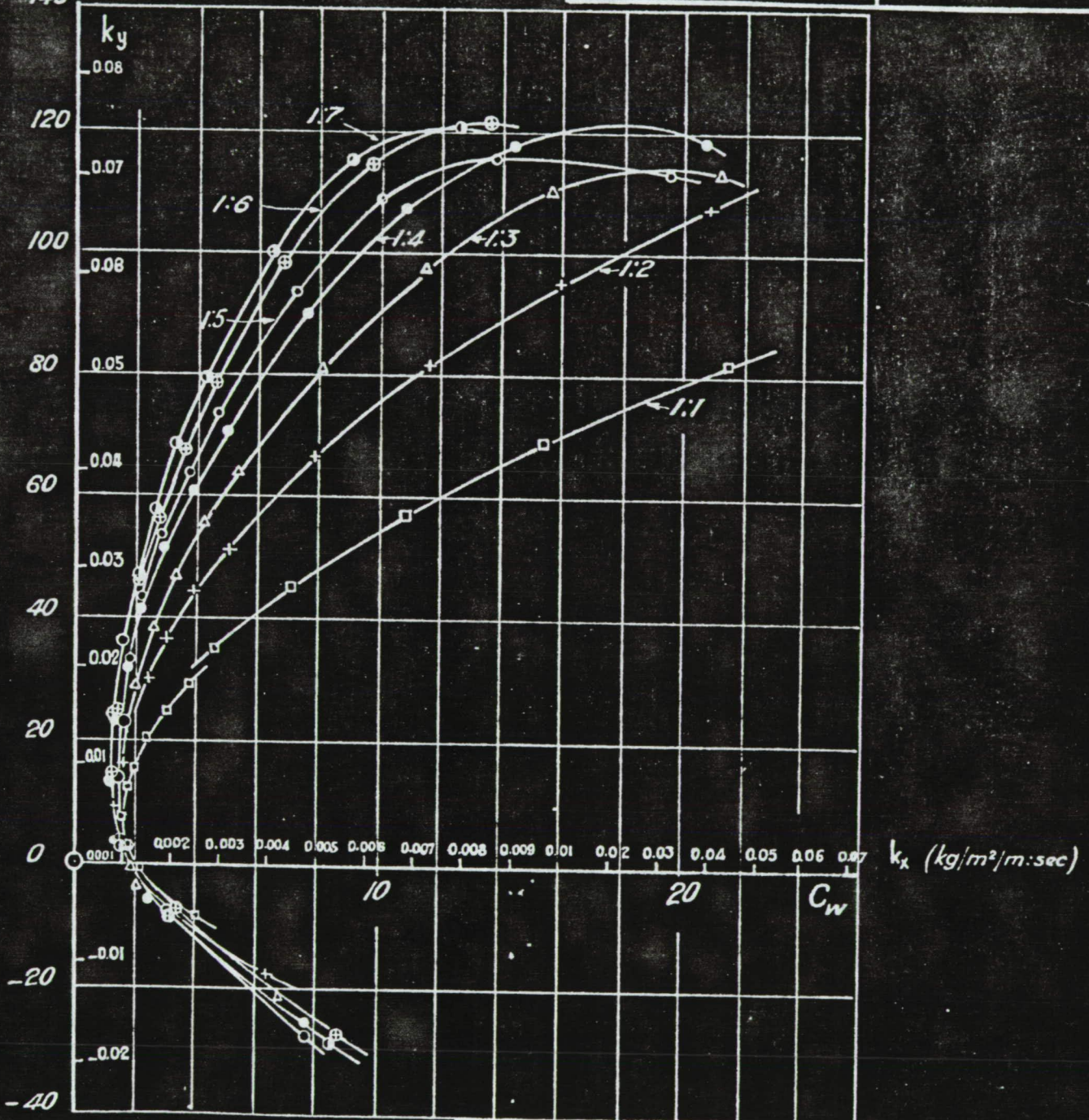
DESIGNED
DRAWN *Paul 7-7-12*
CHECKED
APPROVED

B 34

POLARS OF WINGS OF DIFFERENT
ASPEC RATIO

C_g

140



A-4-B

NTIS does not permit return of items for credit or refund. A replacement will be provided if an error is made in filling your order, if the item was received in damaged condition, or if the item is defective.

Reproduced by NTIS
National Technical Information Service
U.S. Department of Commerce
Springfield, VA 22161

**This report was printed specifically for you
order from our collection of more than 1.5
million technical reports.**

For economy and efficiency, NTIS does not maintain stock of its vast collection of technical reports. Rather, most documents are printed for each order. Your copy is the best possible reproduction available from our master archive. If you have any questions concerning this document or any order you placed with NTIS, please call our Customer Services Department at (703)487-4660.

Always think of NTIS when you want:

- Access to the technical, scientific, and engineering results generated by the ongoing multibillion dollar R&D program of the U.S. Government.
- R&D results from Japan, West Germany, Great Britain, and some 20 other countries, most of it reported in English.

NTIS also operates two centers that can provide you with valuable information:

- The Federal Computer Products Center - offers software and datafiles produced by Federal agencies.
- The Center for the Utilization of Federal Technology - gives you access to the best of Federal technologies and laboratory resources.

For more information about NTIS, send for our **FREE NTIS Products and Services Catalog** which describes how you can access this U.S. and foreign Government technology. Call (703)487-4650 or send this sheet to NTIS, U.S. Department of Commerce, Springfield, VA 22161. Ask for catalog, PR-827.

Name _____
Address _____

Telephone _____

NTIS

**- Your Source to U.S. and Foreign Government
Research and Technology.**